International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(1): 3127-3131

Received: 14-11-2019
Accepted: 16-12-2019

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Yield and quality of mango (*Mangifera indica* L.) as influenced by foliar application of urea and growth regulator

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Abstract
The present investigation entitled "Yield and quality of mango (*mangifera indica* l.) as influenced by foliar application of urea and growth regulator" was conducted at Fruit Research Station, Imalia, Jabalpur during the year 2017-18 and 2018-19. Qualitative characteristics of twenty treatments were studied. V2N2D2 was the most promising among the all twenty treatments for TSS V1 (18.7^{0}B), N2 (19.43^{0}B) D2 (18.33^{0}B) and interaction value V2N2D2 (19.0^{0}B), V2N2 (19.89^{0}B), D2N2 (19.83^{0}B), V1D2 (19.0^{0}B). TSS: acid V2 (73.52), N2 (68.40), D2 (61.74) interaction value V2N2D2 (85.62), V1N2 (83.03), D2N2 (70.97), V1D2 (74.64). Total sugar V2 (17.73), N2 (18.36), D2 (17.31) interaction value V2N2D2 (19.93), V2N2 (19.93), D2N2 (19.10), V2D2 (18.06). Reducing sugar V1 (5.34), N2 (5.53) D2 (4.97) and interaction value V2N2 (6.02), D2N2 (5.63). Non reducing sugar V2 (12.38), N2 (12.34), D2 (12.34) interaction value V2N2D2 (13.27), V2N2 (13.09), D2N2 (13.47). Ascorbic acid V2 (55.59), N2 (56.94), D2 (53.45) interaction value V2N2D2 (62.68), V2N2 (59.90), D2N2 (59.38). Fruit yield V1 (60.32), N2 (60.66), D2 (57.68) interaction value V1N2D2 (68.17), V1N2 (67.26), D2N2 (67.87), V1D2 (61.10). The lowest acorbic acid V2 (0.254%), N1 (0.297%), D2 (308%) interaction value V2N1D2 (346%), V2N2 (0.240%), D2N2 (0.291%), V2D2. This treatment can be used for commercial purpose the study revealed that there was a wide variation whereas the biochemical characteristics, treatment V2N2D2 showed maximum values whereas V1N2D2 shows maximum fruit yield.

Keywords: mango, langra, amrapali, TSS, acidity, acorbic acid

Introduction
Mango belongs to the family Ancardiaceae. It is probably originated in South -East Asia precisely in the Indo-Burma region and most cultivated and favorite fruit of the tropical region after citrus and banana (Merwad *et al.* 2016 and Sahoo *et al.* 2014) [7, 8]. Mango occupies a pre-eminent place amongst the fruit crops grown in India and is acknowledged as the king of the fruit of the country. It is an evergreen tree bearing numerous branches. Inflorescence of mango is large panicles which are grown terminally. Mango is andro-monoecious i.e. each inflorescence bears both hermaphrodite and staminate flowers (Yeshitela *et al.*, 2003) [12]. Mango is consumed at all stages and the nutritional value of mango varies from variety to variety and developmental stages of the fruit including mature and ripened stage. It is an excellent source of vitamin A and C (1082 IU and 36.4 mg fruit^{-1}), as well as good source of calories (60 k cal), protein (0.82g), total carbohydrate (14.98g), fat (0.38g), sodium (1mg), potassium (14mg) per 100 g. Mango is being grown in more than 87 countries of the world but India ranks first among world's mango producing countries. Currently mango covers an area of 2.516 Mha with a production of 18.431 MT, which works out to a low average productivity of 7.3 MT/ha (Anonymous, 2015) [1]. The important mango producing states are Andhra Pradesh, Uttar Pradesh Bihar, Karnataka Tamil Nadu West Bengal Orissa, and Maharashtra. In Madhya Pradesh, total area under mango cultivation comes around 0.252 Mha with a total production of 3.76 MT (Singh *et al.*, 2014) [11]. In Madhya Pradesh it is grown in all district moreover commercially cultivated in Hoshangabad, Betul, Rewa, Satna and Bhopal.

Material and methods
The investigation deals with the "Yield and quality of mango (*mangifera indica* L.) as influenced by foliar application of urea and rowth regulator". For this a field experiment was conducted at Fruit Research Station, Department of Horticulture and the chemical analysis of

fruits was done in the laboratory of the Department of Food Science and Technology, JNKVV, Jabalpur (M.P.) during the year 2017-18 and 2018-19. For the study, sixty plants of mango var. Langra and Amrapali were randomly selected and replicated thrice. The observations were recorded from sixty plants which were selected randomly and tagged in each replication. Spraying was done on the tree canopy by the foot sprayer during first week of October and at the time of 50% flowering. It was considered that 5 lit. Of solution is sufficient for tree spray. So for making the 5 lit. Solution of required treatment, required quantities of growth regulators and micronutrient were dissolved in water. The unripe, sorted diseased, damaged and off type fruits were discarded. The selected fruits were thoroughly washed with tap water to remove dirt and dust particles adhering to the surface of fruit and were allowed for surface drying. The good quality sorted fruits were picked up and used for the purpose of experimentation. Observation on traits *viz.,* Total soluble sugars (°Brix), titrable acidity % and Ascorbic acid, total sugar %, reducing sugar %, non-reducing sugar % and yield of mango content were recorded from randomly selected fruits. The Total soluble solids were estimated in term of percent with the help of hand refractometer. Titrable acidity was estimated by titrating 10 ml juice against 0.1 N NaOH using phenolphthalein as indicator. The acidity was determined in terms of lactic acid. The volume of alkali used was noted and calculated using the following formula:

$$\% \text{ Titrable acidity} = \frac{\text{Normality of NaOH} \times 0.009}{\text{Weight of sample (g))}} \times 100$$

Ascorbic acid content of fruits was determined using standardized 2, 6-dichlorophenol indophenol dye and expressed in mg per 100 g of pulp. The sugars content of the sample was determined by the procedure as described by and fruit yield fresh fruits were picked out from the tree as per treatment and weighed with the use of physical balance and expressed yield in kg plant^{-1}. The data collected on all the quantitative characters were subjected to Double Split plot Design analysis and following different statistical parameters were worked out using OP Sheoran Programmer, SPSS statistical software. The data collected on all the quantitative characters were subjected to Split Split Plot Design analysis and following different statistical parameters were worked out using OP Sheoran Programmer, SPSS statistical software.

Treatment details

Treatments Symbol	Treatments
V1N1D1	Variety Langra + Tap water
V1N1D2	Variety Langra + Distilled water
V1N2D1	Variety Langra + Urea 2%
V1N2D2	Variety Langra + Urea 4%
V1N3D1	Variety Langra + Borex 0.2%
V1N3D2	Variety Langra + Borex 0.5%
V1N4D1	Variety Langra + Zinc sulphate 0.2%
V1N4D2	Variety Langra + Zinc sulphate 0.5%
V1N5D1	Variety Langra + NAA 100 ppm
V1N5D2	Variety Langra + NAA 200 ppm
V2N1D1	Variety Amrapali + Tap water
V2N1D2	Variety Amrapali + Distilled water
V2N2D1	Variety Amrapali + Urea 2%
V2N2D2	Variety Amrapali + Urea 4%
V2N3D1	Variety Amrapali + Borex 0.2%
V2N3D2	Variety Amrapali + Borex 0.5%
V2N4D1	Variety Amrapali + Zinc sulphate 0.2%
V2N4D2	Variety Amrapali + Zinc sulphate 0.5%
V2N5D1	Variety Amrapali + NAA 100 ppm
V2N5D2	Variety Amrapali + NAA 200 ppm

Results and Discussion

The significantly improvement in quality of fruits was found due to imposing of the treatments in mango (Table 1 to 7). The fruit quality in terms of minimum acidity, maximum TSS, TSS: Acid ratio, total sugar, reducing sugar and non-reducing sugar (0.254%, 18.73^{0}B, 73.52, 17.73%, 5.34% and 12.38%) respectively were observed in Amrapali, while maximum ascorbic acid content (55.59mg/100g) was noted in Langra. With respect to nutrients application the effective results were found and the minimization in acidity was noted while, maximum TSS, TSS: Acid ratio, total sugar, reducing sugar, non-reducing sugar and ascorbic acid (0.297%, 19.43^{0}B, 68.40, 18.36%, 5.53%, 12.38% and 56.94mg/100g) respectively were recorded with the application of urea.

In case of doses, minimum acidity, maximum TSS, TSS: Acid ratio, total sugar, reducing sugar, non-reducing sugar and ascorbic acid (0.308%, 18.33^{0}B, 61.74, 17.31%, 4.97%, 12.34% and 53.45mg/100g) was observed with the higher dose of urea i.e. 4%.

The interaction of variety × nutrients exhibited the minimum acidity, maximum TSS, TSS: Acid ratio, total sugar reducing sugar and non-reducing sugar (0.240%, 19.89^{0}B, 83.03, 19.93%, 6.02% and 13.09%) were recorded with the Amrapali × urea and the ascorbic acid (59.90mg/100g) was noted with Langra × urea. Similarly the combined effect of nutrients × doses minimized the acidity while, improve trends of the TSS, TSS: Acid ratio, total sugar, reducing sugar, non-reducing sugar and ascorbic acid (0.291%, 19.83^{0}B, 70.97, 19.10%, 5.63%, 13.47% and 59.38mg/100g) respectively were observed in urea 4%. The interplay of variety × doses also showed the maximum TSS, and total sugar (19.00^{0}B, 18.06%) observed in Amrapali × higher dose of urea. While, maximum ascorbic acid (56.93mg/100g) was noted in Langra × higher dose of urea. The interaction of variety × nutrients × doses improved the quality parameter while, the maximum total sugar, reducing sugar and non-reducing sugar (19.93%, 6.18% and 13.27%) respectively were recorded in Amrapali × urea × higher dose i.e. 4%. Quality of mango fruit is not

uniform or the quality of mango cannot be determined by one factor it might be effect by varietal genetic constitution, age of plant, relative humidity, soil moisture, temperature and supply of nutrients, application of urea partial responsible to the quality of fruit this may be due to maintaining the optimum level of nitrogen which stimulates enzymatic activities which are essential for the chemical changes like hydrolysis of polysaccharides and its conversion into sugar gives an indication of total soluble solid (Hada and Singh 2018) [2]. Reported that the mango varieties Amrapali were the sweetest variety with maximum TSS and TSS/acid ratio (Hossain *et al.,* 2001, Kishore *et al.,* 2015) [3, 4]. The mobilization of carbohydrates to organic acid may be the possible cause behind the inherent TSS of a particular variety, and the fruit acidity is responded to the ripening stage of the variety. It is also depended on prevailing environmental conditions. The variation in the acidity in different varieties of mango could be due to their varietal characters (Hada and Singh 2018) [2].

The highest total sugar attributed to the involvement of nitrogen in various energy sources like amino acids and amino sugar might be due to catalytic activity of several enzymes, which participates in the conversion of sugar (Sharma *et al.,* 2013) [13]. Kumar *et al.* (2008) [5] reported that increased total sugar in apple fruit due to accumulation of more photosynthesis might be ascribed to uptake of more nitrogen in plant system. Who evaluated the association of urea @ 4% with variety Amrapali enhancement in quality of fruit could be due to the catalytic action of nutrients particularly at higher concentration, hence the foliar application of nutrients quickly increased the uptake in tissues and organs of the mango plants and decrease the deficiencies and improve the fruit quality.

The highest fruit yield (60.32kg plant^{-1}) were noted in variety Langra (Table-8). In case of individual effect of nutrients, the maximum fruit yield 66.66 kg plant^{-1}) noted with the application of urea. The doses of nutrients also increased the fruit yield 57.68kg plant^{-1} was observed with the application of higher dose of urea. Increasing trends of fruit yield were significantly associated with the combination of variety × nutrients exhibited the maximum fruit yield (67.26 kg plant^{-1}) was noted with Langra × urea. The combination between nutrients × doses enhanced the fruit yield and showed that the maximum fruit yield 67.87 kg plant^{-1} were noted with the application of urea 4%. Similarly interaction between variety × doses also accelerated fruit yield 61.10 kg plant^{-1} were also noted with Langra + higher dose of nutrients. The interaction among the variety × nutrients × doses influenced significantly the yield attributes and showed the maximum fruit yield 68.17 kg plant^{-1} recorded in Langra + urea 4%. Study that the foliar application 4% (Kumar *et al.,* 2008, Sarker and Rahim 2013) [5, 9].

Table 1: Effect of nutrients and naphthalene acetic acid on TSS (^{0}Brix)

Treatments	Varieties			Doses		
	V1	V2	Mean	D1	D2	Mean
Water (N1)	16.25	17.79	17.02	17.02	17.02	17.02
Urea (N2)	18.98	19.89	19.43	19.04	19.83	19.43
Borex (N3)	18.31	19.37	18.84	18.37	19.31	18.84
Zinc sulphate (N4)	16.96	18.72	17.84	17.15	18.53	17.84
NAA (N5)	15.93	17.89	16.91	16.83	16.99	16.91
Mean	17.29	18.73		17.68	18.33	
	Varieties					
Doses	V1	V2	Mean			
D1	16.90	18.46	17.68			
D2	17.67	19.00	18.33			
Mean	17.29	18.73				
	SEm±	CD at 5%				
Variety (V)	0.07	0.22				
Nutrients (N)	0.13	0.39				
Doses (D)	0.08	0.23				
(V×N)	0.18	0.18				
(N×D)	0.17	0.51				
(V×D)	0.11	0.33				

Table 2: Effect of nutrients and naphthalene acetic acid on acidity (%)

Treatments	Varieties			Doses		
	V1	V2	Mean	D1	D2	Mean
Water (N1)	0.387	0.269	0.328	0.325	0.331	0.328
Urea (N2)	0.354	0.240	0.297	0.302	0.291	0.297
Borex (N3)	0.355	0.243	0.299	0.302	0.297	0.299
Zinc sulphate	0.362	0.259	0.310	0.312	0.309	0.310
NAA (N5)	0.368	0.263	0.316	0.317	0.315	0.316
Mean	0.365	0.254		0.311	0.308	
	Varieties					
Doses	V1	V2	Mean			
D1	0.367	0.363	0.311			
D2	0.256	0.253	0.308			
Mean	0.365	0.254				
	SEm±	CD at 5%				
Variety (V)	0.466	1.398				
Nutrients (N)	0.735	2.205				
Doses (D)	0.001	0.004				
(V×N)	0.002	0.005				
(N×D)	0.002	0.005				
(V×D)	0.001	NS				

Treat.	Variety (V1)					Variety (V2)				
	N1	N2	N3	N4	N5	N1	N2	N3	N4	N5
D1	0.384	0.361	0.355	0.365	0.370	0.265	0.244	0.248	0.259	0.263
D2	0.390	0.346	0.355	0.358	0.366	6.851	0.236	0.238	0.259	0.263
	SEm±					CD at 5%				
V × N × D	0.002					NS				

Table 3: Effect of nutrients and naphthalene acetic acid on TSS Acid ratio

Treatments	Varieties			Doses		
	V1	V2	Mean	D1	D2	Mean
Water (N1)	42.01	64.24	53.13	54.76	51.50	53.13
Urea (N2)	53.77	83.03	68.40	65.83	70.97	68.40
Borex (N3)	51.60	79.79	65.70	63.31	68.09	65.70
Zinc sulphate (N4)	46.97	72.44	59.70	57.30	62.10	59.70
NAA (N5)	43.32	68.08	55.70	55.36	56.04	55.70
Mean	47.53	73.52		59.31	61.74	
	Varieties					
Doses	V1	V2	Mean			
D1	46.16	72.46	59.31			
D2	48.91	74.57	61.74			
Mean	47.53	73.52				
	SEm±	CD at 5%				
Variety (V)	0.088	0.264				
Nutrients (N)	0.15	0.45				
Doses (D)	0.13	0.39				
(V×N)	0.21	0.64				
(N×D)	0.30	0.87				
(V×D)	0.19	NS				

Treat.	Variety (V1)					Variety (V2)				
	N1	N2	N3	N4	N5	N1	N2	N3	N4	N5
D1	42.42	51.36	49.98	44.37	42.66	67.09	80.30	76.63	70.24	68.06
D2	41.60	56.17	53.23	49.57	43.97	61.40	85.76	82.95	74.64	68.10
	SEm±					CD at 5%				
V × N × D	0.42					1.24				

Table 4: Effect of nutrients and naphthalene acetic acid on ascorbic acid (mg/100g)

Treatments	Varieties			Doses		
	V1	V2	Mean	D1	D2	Mean
Water (N1)	50.80	44.20	47.50	48.09	46.91	47.50
Urea (N2)	59.90	53.98	56.94	54.50	59.38	56.94
Borex (N3)	58.20	51.30	54.75	52.42	57.08	54.75
Zinc sulphate (N4)	55.90	48.68	52.29	51.39	53.20	52.29
NAA (N5)	53.13	46.53	49.83	48.99	50.67	49.83
Mean	55.59	48.94		51.08	53.45	
	Varieties					
Doses	V1	V2	Mean			
D1	54.24	47.91	51.08			
D2	56.93	49.96	53.45			
Mean	55.59	48.94				
	SEm±	CD at 5%				
Variety (V)	0.09	0.27				
Nutrients (N)	0.13	0.38				
Doses (D)	0.08	0.24				
(V×N)	0.18	0.54				
(N×D)	0.18	0.54				
(V×D)	0.12	0.34				

Treat.	Variety (V1)					Variety (V2)				
	N1	N2	N3	N4	N5	N1	N2	N3	N4	N5
D1	51.39	57.12	55.72	54.69	52.29	44.79	51.88	49.12	48.09	45.69
D2	50.21	62.68	60.68	57.12	53.97	43.62	56.08	53.48	49.28	47.37
	SEm±					CD at 5%				
V × N × D	0.26					NS				

Table 5: Effect of nutrients and naphthalene acetic acid on total sugar (%)

Treatments	Varieties			Doses		
	V1	V2	Mean	D1	D2	Mean
Water (N1)	14.62	16.24	15.43	15.68	15.17	15.43
Urea (N2)	17.60	19.11	18.36	17.62	19.10	18.36
Borex (N3)	16.85	18.65	17.75	17.36	18.14	17.75
Zinc sulphate (N4)	16.59	17.73	17.16	16.81	17.51	17.16
NAA (N5)	16.08	16.89	16.48	16.34	16.63	16.48
Mean	16.35	17.73		16.76	17.31	
	Varieties					
Doses	V1	V2	Mean			
D1	11.80	12.17	16.76			
D2	12.08	12.60	17.31			
Mean	16.35	17.73				
	SEm±	CD at 5%				
Variety (V)	0.10	0.32				
Nutrients (N)	0.07	0.21				
Doses (D)	0.04	0.13				
(V×N)	0.10	0.30				
(N×D)	0.10	0.28				
(V×D)	0.06	0.18				

Treat.	Variety (V1)					Variety (V2)				
	N1	N2	N3	N4	N5	N1	N2	N3	N4	N5
D1	14.79	16.93	16.71	16.28	15.97	16.58	18.30	18.02	17.33	16.72
D2	14.44	18.28	16.99	16.89	16.18	15.91	19.93	19.29	18.13	17.07
	SEm±					CD at 5%				
V × N × D	0.13					0.40				

Table 6: Effect of nutrients and naphthalene acetic acid on reducing sugar (%)

Treatments	Varieties			Doses		
	V1	V2	Mean	D1	D2	Mean
Water (N1)	4.23	4.73	4.48	4.55	4.40	4.48
Urea (N2)	5.03	6.02	5.53	5.42	5.63	5.53
Borex (N3)	4.58	5.72	5.15	4.81	5.50	5.15
Zinc sulphate (N4)	4.20	5.27	4.73	4.61	4.86	4.73
NAA (N5)	3.98	4.96	4.47	4.49	4.45	4.47
Mean	4.40	5.34		4.78	4.97	
	Varieties					
Doses	V1	V2	Mean			
D1	4.33	5.22	4.78			
D2	4.48	5.46	4.97			
Mean	4.40	5.34				
	SEm±	CD at				
Variety (V)	0.004	0.012				
Nutrients (N)	0.04	0.13				
Doses (D)	0.02	0.07				
(V×N)	0.06	0.18				
(N×D)	0.05	0.15				
(V×D)	0.03	NS				

Treat.	Variety (V1)					Variety (V2)				
	N1	N2	N3	N4	N5	N1	N2	N3	N4	N5
D1	4.30	4.97	4.18	4.24	3.97	4.81	5.87	5.43	4.98	5.02
D2	4.15	5.09	4.98	4.17	3.99	4.66	6.18	6.02	5.55	4.91
	SEm±					CD at 5%				
V × N × D	0.07					0.21				

Table 7: Effect of nutrients and naphthalene acetic acid on non-reducing sugar (%)

Treatments	Varieties			Doses		
	V1	V2	Mean	D1	D2	Mean
Water (N1)	10.39	11.51	10.95	11.13	10.77	10.95
Urea (N2)	12.58	13.09	12.83	12.20	13.47	12.83
Borex (N3)	12.27	12.93	12.60	12.56	12.64	12.60
Zinc sulphate (N4)	12.38	12.46	12.42	12.20	12.65	12.42
NAA (N5)	12.10	11.93	12.01	11.85	12.18	12.01
Mean	11.94	12.38		11.99	12.34	
	Varieties					
Doses	V1	V2	Mean			
D1	11.80	12.17	11.99			
D2	12.08	12.60	12.34			
Mean	11.94	12.38				
	SEm±	CD at 5%				
Variety (V)	0.05	0.15				
Nutrients (N)	0.10	0.31				
Doses (D)	0.06	0.17				
(V×N)	0.14	0.43				
(N×D)	0.13	0.37				
(V×D)	0.08	NS				

Treat.	Variety (V1)					Variety (V2)				
	N1	N2	N3	N4	N5	N1	N2	N3	N4	N5
D1	10.49	11.97	12.53	12.04	12.00	11.77	12.43	12.59	12.35	11.70
D2	10.29	13.19	12.01	12.73	12.19	11.25	13.75	13.27	12.58	12.16
	SEm±					CD at 5%				
V × N × D	0.18					0.53				

Table 8: Effect of nutrients and naphthalene acetic acid on fruit yield (kg/tree)

Treatments	Varieties			Doses		
	V1	V2	Mean	D1	D2	Mean
Water (N1)	53.67	45.01	49.34	50.75	47.93	49.34
Urea (N2)	67.26	66.07	66.66	65.45	67.87	66.66
Borex (N3)	62.68	54.91	58.79	57.31	60.28	58.79
Zinc sulphate (N4)	60.82	54.14	57.48	56.35	58.61	57.48
NAA (N5)	57.17	48.57	52.87	52.05	53.69	52.87
Mean	60.32	53.74		56.38	57.68	
	Varieties					
Doses	V1	V2	Mean			
D1	59.54	53.22	56.38			
D2	61.10	54.25	57.68			
Mean	60.32	53.74				
	SEm±	CD at 5%				
Variety (V)	0.03	0.09				
Nutrients (N)	0.13	0.40				
Doses (D)	0.06	0.17				
(V×N)	0.19	0.57				
(N×D)	0.13	0.39				
(V×D)	0.08	0.24				

Treat.	Variety (V1)					Variety (V2)				
	N1	N2	N3	N4	N5	N1	N2	N3	N4	N5
D1	54.73	66.35	60.62	59.52	56.49	46.77	64.56	54.01	53.17	47.62
D2	52.62	68.17	64.74	62.12	57.86	43.24	67.58	55.82	55.11	49.52
	SEm±					CD at 5%				
V × N × D	0.19					0.55				

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